

**MULTIVARIATE ANALYSIS OF THE MORPHOLOGICAL
VARIABILITY AMONG *BARBUS PELOPONNESIUS*
(CYPRINIDAE) POPULATIONS FROM GREECE AND TWO
POPULATIONS OF *B. MERIDIONALIS MERIDIONALIS*
AND *B. MERIDIONALIS PETENYI***

by

Yiannis KARAKOUSIS (1), Costas PEIOS (1), Panayiotis S. ECONOMIDIS (2)
and Costas TRIANTAPHYLLIDIS (1)

ABSTRACT. - Morphological differentiation among *Barbus peloponnesius*, *B. meridionalis petenyi* and *B. meridionalis meridionalis* has been investigated using multivariate morphometric analysis. *B. peloponnesius* and *B. m. petenyi* form a group distinct from the *B. m. meridionalis*. These findings support the Karaman's classification (1971) of *B. peloponnesius* as a distinct species and also indicate that *B. peloponnesius* and *B. m. petenyi* probably constitute one species. Furthermore, differences among the *B. peloponnesius* populations indicate the existence of at least two subspecies in Greece.

RÉSUMÉ. - Les différences morphologiques entre les taxa *Barbus peloponnesius*, *B. meridionalis petenyi* et *B. m. meridionalis* ont été étudiées en utilisant des méthodes de l'analyse multifactorielle. *B. peloponnesius* et *B. meridionalis petenyi* forment un groupe distinct de *B. m. meridionalis*. La classification proposée par Karaman (1971) selon laquelle *B. peloponnesius* est une espèce valide est vérifiée, et *B. peloponnesius* et *B. meridionalis petenyi* constituent probablement une seule espèce. De plus, les différences entre les populations de *B. peloponnesius* en Grèce indiquent qu'elles appartiennent au moins à deux sous-espèces distinctes.

Key-words. - Cyprinidae, *Barbus meridionalis*, *Barbus peloponnesius*, Greece, Multivariate analysis, Morphometrics.

The genus *Barbus* is one of the most diverse in the family Cyprinidae; it includes approximately 800 species (Howes, 1987). In Europe the Iberian and the Greek peninsulae are the most speciose areas. According to Economidis (1989) the lakes and rivers of Greece are inhabited by seven species of *Barbus*: *B. peloponnesius* Valenciennes, 1842; *B. cyclolepis* Heckel, 1840; *B. prespensis* Karaman, 1924; *B. euboicus* Stephanidis, 1950; *B. graecus* Steindachner, 1895; *B. barbus* Linnaeus, 1758; and *B. albanicus* Steindachner, 1870.

Barbus peloponnesius was described from specimens caught in the Alpheios river in Peloponnesus. It is one of the most widely distributed barbel species in Greece. It can be found in western and north-western Greece, in contrast to the other common rheophilic species *B. cyclolepis* which is distributed in north-eastern and central parts of the country. For many years *B. peloponnesius* was classified as a synonym of *B. meridionalis* Risso, 1826 of southern France and north-western Italy.

(1) Department of Genetics, Development and molecular Biology, and

(2) Department of Zoology, School of Biology, Aristotle University of Thessaloniki, GR-540 06 Thessaloniki, GREECE.

In his revision of the genus *Barbus* Karaman (1971), using a wide range of morphological features, recognized *B. peloponnesius* as a valid species differing from *B. meridionalis* in the shape of the head and of the snout. However Almaça (1984), on the basis of the "total similarity" of the morphological characters, classified *B. peloponnesius* as one of the three subspecies of *B. meridionalis*, the others being *B. meridionalis meridionalis* of northern Spain and southern France and *B. meridionalis petenyi* of the Danube and Vistula basins. Furthermore, he pointed out that some of the populations of *B. meridionalis peloponnesius* in northern Greece have characters intermediate between *B. m. petenyi* and *B. m. peloponnesius* subspecies. Thus, the systematic status of this species in Greece has been a matter of debate and only scattered information exists (Stephanidis, 1939, 1971; Kattoulas, 1972; Triantaphyllidis *et al.*, 1981; Economidis, 1989, 1990).

The use of morphological characters in taxonomic studies has some disadvantages due to their polygenic inheritance and to considerable environmental influence. Nevertheless, multivariate analysis of a set of phenotypic characters can be regarded as an appropriate method to clarify morphological relationships of different populations of a species and to detect racial affinities (Thorpe, 1976, 1987). Another problem is the kind of characters which are used. Some data sets for morphometric purposes in ichthyology have been composed of traditional characters e.g., standard length, maximum body depth, etc. These measurements can introduce biases due to an unequal coverage of the body of the fish. According to Strauss and Bookstein (1982) these problems can be overcome using a "Truss network" method, which produces a more systematic geometric characterization of fish shape and has demonstrated increased resolving power for describing shape differences. This paper reports the use of multivariate methods in an attempt to examine the morphological differentiation among different populations of *B. peloponnesius* from Greece and to compare them with other populations belonging to the *B. meridionalis meridionalis* and *B. meridionalis petenyi*.

MATERIALS AND METHODS

The analysis was based on samples preserved in the Zoological Museum of the School of Biology of the University of Thessaloniki. Sixteen populations were investigated. Fourteen came from different areas of Greece (Fig. 1) and have been classified as *B. peloponnesius* or *B. meridionalis*. One sample came from the Danube river system (River Arges, Rumania) and represents *B. meridionalis petenyi* and another came from the River Hérault in southern France and this represents *B. meridionalis meridionalis*. Table I gives the samples examined, date of capture of specimens and samples sizes.

Table I. - Samples examined, date of capture, and sample's size. The numbers in parentheses refer to collection sites in figure 1.

Population	Date	Sample size	Population	Date	Sample size
Alpheios (1)	August 1977	46	Aliakmon (9)	June 1988	34
Mornos (2)	August 1977	32	Tripotamos (10)	September 1988	35
Evinos (3)	July 1977	40	Aridea (11)	November 1987	23
Acheloos (4)	July 1977	5	Edesseos (12)	September 1977	50
Arachthos (5)	November 1977	10	Axios (13)	November 1977	35
Acheron (6)	October 1977	18	Gallikos (14)	July 1971	20
Kalamas (7)	October 1977	35	France (Hérault)	March 1990	9
Aoos (8)	August 1987	44	Danube (Arges)	September 1965	23

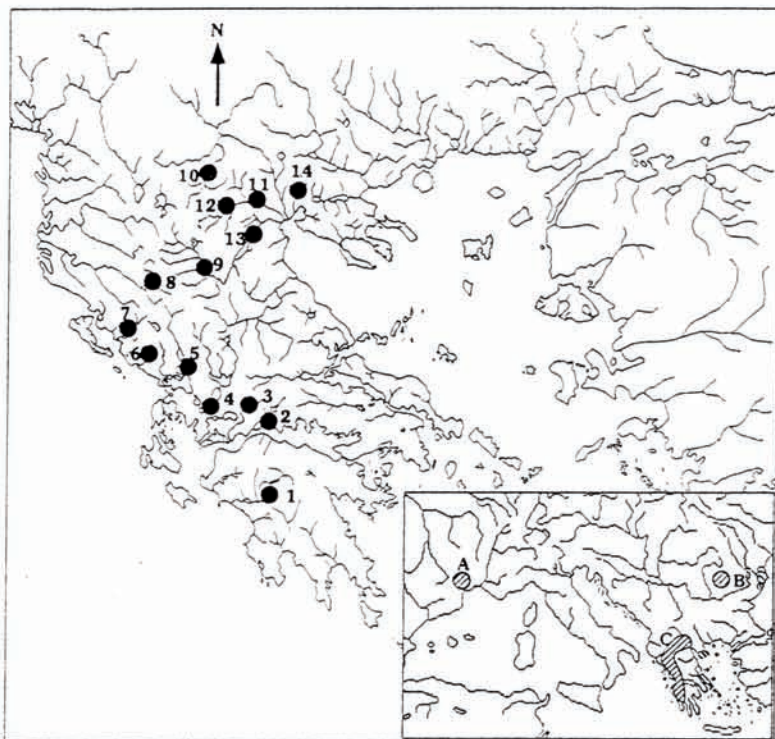


Fig. 1. - Collection sites. 1: Alpheios; 2: Mornos; 3: Evinos; 4: Acheloos; 5: Arachthos; 6: Acheron; 7: Kalamas; 8: Aoos; 9: Aliakmon; 10: Tripotamos; 11: Aridea; 12: Edesseos; 13: Axios; 14: Gallikos. In set, the sampling sites of the three taxa. A: *Barbus meridionalis*; B: *B. petenyi*; C: *B. peloponnesius*.

Twenty morphometric and six meristic characters were measured according to Hubbs and Lagler (1967). The characters used were: standard length (SL), maximum body depth, minimum body depth, caudal peduncle length, head length, diameter of eye, preorbital distance, postorbital distance, dorsal fin height, dorsal fin base length, anal fin height, pectoral fin length, pelvic fin length, distance between pectoral and pelvic fins, distance between pelvic and anal fins, distance dorsal-pectoral, distance dorsal-pelvic, distance dorsal-anal, distance dorsal-caudal, distance anal-caudal. Meristic characters were: number of rays in dorsal, anal, pectoral, pelvic, caudal fins and number of scales of the lateral line. "Truss network" measurements were according to Corti *et al.* (1988). Fin rays, included all detectable rays, were counted at the fin base. All morphometric measurements were taken to the nearest 0.1 mm using callipers. The full data files are available on request.

Preliminary analysis indicated that there were significantly different allometric growth regressions (character length = aSL^b) for each morphometric character among populations. Therefore, before analysis all morphometric measurements were standardized according to the formula:

$$e = \log_{10} Y - \beta (\log_{10} X - \log_{10} X_{SL})$$

where: e = standardized measurement; Y = character length; β = slope of $\log_{10} Y$ against $\log_{10} X$ plot for each population; X = standard length of the specimen; X_{SL} = mean standard length over all specimens.

According to Reist (1985) this transformation best reflects shape variation among groups which is independent of size factors.

A stepwise discriminant analysis was used, based on the generalised Mahalanobis distance, to determine the similarity between the populations. The analysis was carried out using the SPSS (1979) routines. Based on the Mahalanobis distance a dendrogram was constructed using the unweighted pair-group method with arithmetic averaging (UPGMA).

RESULTS

The mean and standard deviation of the morphometric and meristic characteristics, in the populations examined, are shown in table II. Figure 2 shows the range and the mean of the standard length (SL). Discriminant analysis indicated that two populations differentiated substantially from the others: the population from France and the population from Gallikos river (Fig. 3). The rest of the Greek populations and the sample from the Danube basin were clustered together. The characters of main importance in discriminating among populations are for each axis: the height of the dorsal fin and the maximum and the minimum body depth. The same results are shown at the UPGMA dendrogram where the Mahalanobis distance were used (Fig. 4).

In the next analysis we excluded the two more differentiated populations (Fig. 5). In this case the main characters in discriminating among populations were the length of the pectoral fin and the base length of the dorsal fin.

The discriminant analysis of the "Truss network" measurements did not give a better resolution (Fig. 6) and did not substantially alter the results previously obtained. Almost all populations examined were identical for most meristic characters. A slight variation was found for some characters and the general pattern was: D: III/8-9, A: III/5, P: I/13, V: I/7-8, C: I/18-19. Thus, these characters can not be used for the evaluation of the affinities among the populations. On the other hand, the scales of the lateral line showed a great amount of variation. (Fig. 7, Table II).

DISCUSSION

As indicated from the results of the first discriminant analysis and the dendrogram of the Mahalanobis distance, the sample from southern France, which had been classified as *B. meridionalis meridionalis*, differed substantially from the other samples. Furthermore, this sample has a low number of lateral line scales, a character that is typical for *B. meridionalis*. This seems to support the opinion of Karaman (1971) that *B. peloponnesius* is distinct at species level from *B. meridionalis*.

The sample from the Danube system clustered in both analyses with the "*peloponnesius*" group. The tendency of this sample to resemble that from the Axios river and its tributaries indicates that there has probably been gene flow between these populations via the Morava river. There has been disagreement about the taxonomic status of *Barbus petenyi* (Heckel and Kner, 1858). Some authors consider it to be a distinct species (e.g., Rolik, 1971; Witkowski, 1973) and others as a subspecies of *B. meridionalis* (e.g., Koller, 1926; Almaça, 1981, 1984). According to Stephanidis (1971) *B. m. petenyi* differs from *B. m. peloponnesius* by possessing a greater number of lateral-line scales and a longer head and snout. Almaça (1981) confirmed the above statement but he stressed that barbel length is also an important character. The results of our analysis indicated that the "*peloponnesius*" and the "*petenyi*" samples comprise one group. It seems that the *B. m. peloponnesius* and *B. m. petenyi* subspecies, according to Almaça's (1984) classification, form one species and this is separate from *B. meridionalis*. The distribution of *B. m. meridionalis* and *B. peloponnesius* in Europe is shown in figure 8 and indicates that there is no

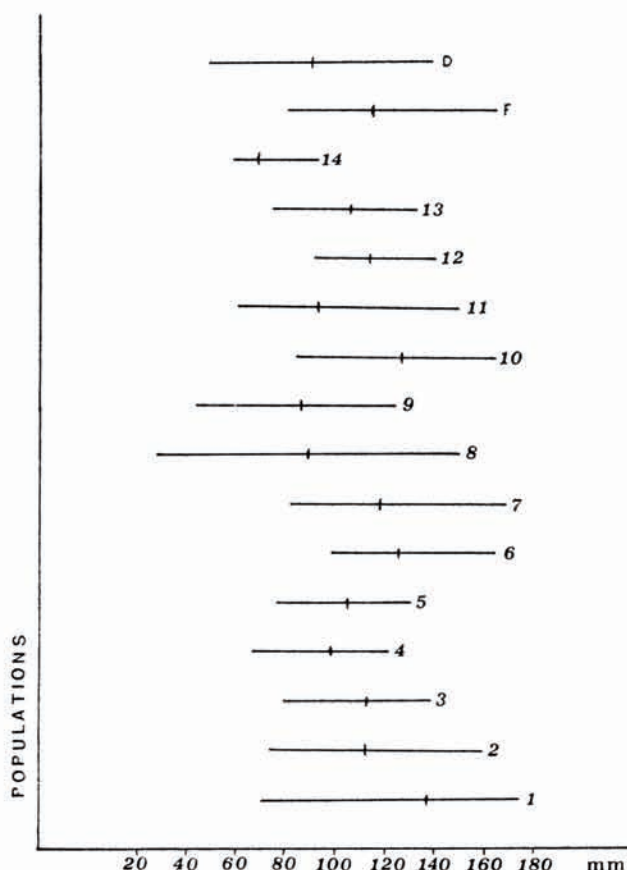


Fig. 2. - Range of standard length in the samples examined. Point indicates the mean values and the number refer to the collection sites in figure 1. D = Danube and F = France.

geographic overlap. Furthermore Persat and Berrebi (1990) proposed that the colonisation of Europe by the *B. meridionalis* lineage started in the oligocene. Since then the populations of the Danube basin have been isolated from those of southern France. Thus the taxa presently recognized as *B. meridionalis* and *B. peloponnesius* seem to be separated in space and in time.

As indicated from the dendrogram and the discriminant analysis, the samples from south-western Greece and the Peloponnesus have a tendency to cluster together. Similarities are also apparent from measurements of the number of scales in the lateral line. It seems that probably a correlation exists between the number of scales and latitude. The samples from south-western Greece and the Peloponnesus can be referred to *B. peloponnesius peloponnesius* while these of northern Greece and the Danube basin should be regarded as *B. peloponnesius petenyi*. The same results were obtained using the "Truss network" method. Many measurements (e.g., distance between dorsal and pectoral fins, distance between dorsal and pelvic fins, etc.) were used in both the truss network and the classical analyses.

The differentiation of the Gallikos population is a problem. This population had been classified as *B. meridionalis petenyi* by Almaça (1981). The Gallikos population is at

Table II. - Mean values and standard deviation (in parentheses), of the morphometric and meristic characters in the populations examined. The numbers beside the population name refer to the collection sites in figure 1.

	Acheloos (4)	Acheron (6)	Alpheios (1)	Alliakmon (9)	Aoos (8)	Ardeia (11)	Arachthos (5)	Axios (13)
Morphometric variables								
Standard length	98.46 (21.4)	124.67 (22.9)	138.35 (14.1)	84.88 (25.3)	88.03 (32.6)	91.08 (15.5)	105.83 (17.1)	105.20 (16.2)
Maximum body depth	21.64 (4.1)	27.66 (4.5)	31.97 (3.1)	17.95 (4.9)	18.76 (6.7)	21.20 (3.5)	22.70 (4.1)	21.54 (2.7)
Minimum body depth	11.30 (2.1)	13.89 (1.9)	14.98 (1.5)	8.82 (2.3)	9.41 (3.2)	10.29 (1.6)	11.32 (1.7)	10.87 (1.5)
Caudal peduncle length	18.72 (4.7)	21.05 (4.1)	24.72 (4.6)	14.31 (5.1)	16.87 (6.2)	16.31 (2.9)	18.10 (3.6)	18.75 (3.1)
Head length	25.84 (5.1)	31.95 (5.2)	35.61 (3.7)	20.90 (5.6)	23.86 (8.2)	24.16 (4.1)	25.59 (3.9)	26.49 (4.1)
Diameter of eye	5.80 (0.6)	5.88 (0.6)	6.60 (0.6)	4.47 (0.8)	4.36 (1.1)	5.56 (0.6)	4.93 (0.3)	5.10 (0.4)
Preorbital distance	10.38 (2.5)	12.92 (2.4)	15.19 (1.9)	8.59 (2.7)	9.75 (3.8)	9.42 (1.9)	10.14 (1.7)	10.43 (1.8)
Postorbital distance	11.28 (2.3)	14.90 (2.8)	16.96 (1.9)	10.01 (3.1)	10.51 (3.7)	10.74 (1.9)	12.23 (2.1)	12.20 (2.1)
Dorsal fin height	13.06 (3.3)	16.44 (3.2)	22.45 (3.6)	10.25 (3.1)	11.28 (4.4)	12.41 (2.3)	12.13 (2.2)	12.84 (2.1)
Dorsal fin base length	22.42 (5.2)	23.85 (6.6)	22.07 (1.6)	15.55 (5.6)	19.05 (8.1)	18.08 (4.6)	21.62 (4.7)	21.88 (5.6)
Anal fin height	8.20 (1.7)	10.48 (2.4)	18.40 (2.8)	7.47 (2.7)	6.74 (2.5)	7.49 (1.4)	7.50 (1.7)	7.87 (1.6)
Pectoral fin length	21.18 (4.1)	23.77 (4.2)	24.81 (2.4)	14.59 (3.9)	17.99 (6.3)	17.88 (2.5)	20.03 (3.1)	19.20 (2.7)
Pelvic fin length	17.98 (3.9)	20.17 (3.3)	25.12 (3.6)	12.01 (3.3)	14.63 (4.9)	15.05 (1.8)	16.58 (2.8)	15.48 (2.3)
Distance pectoral - pelvic fin	27.84 (5.9)	38.05 (7.5)	41.51 (4.9)	24.42 (7.5)	25.23 (9.6)	27.19 (4.9)	31.15 (5.4)	31.79 (4.8)
Distance pelvic - anal fin	22.50 (5.1)	29.18 (5.6)	32.72 (4.7)	19.18 (6.2)	19.44 (7.5)	20.77 (3.8)	24.39 (4.2)	23.15 (4.4)
Distance dorsal - pectoral fin	31.62 (5.9)	39.74 (7.1)	44.18 (4.7)	25.59 (7.8)	27.01 (10.1)	29.23 (5.1)	33.48 (5.5)	31.93 (4.8)
Distance dorsal - pelvic fin	21.10 (4.3)	27.22 (4.5)	30.85 (3.3)	17.54 (4.9)	18.51 (6.7)	20.38 (3.2)	21.75 (3.3)	20.61 (2.7)
Distance dorsal - anal fin	30.96 (7.5)	40.57 (7.8)	45.27 (5.9)	26.05 (7.5)	27.05 (10.4)	29.09 (4.8)	31.10 (4.9)	31.94 (5.4)
Distance dorsal - caudal fin	49.72 (11.4)	61.99 (12.5)	69.73 (8.1)	43.21 (13.8)	43.26 (16.4)	44.42 (6.9)	53.03 (9.1)	51.89 (8.9)
Distance anal - caudal fin	27.66 (5.7)	31.60 (5.6)	36.51 (4.2)	23.12 (8.3)	23.34 (8.8)	23.30 (4.3)	26.59 (5.1)	27.06 (3.9)
Meristic variables								
Number of rays in dorsal fin	9.00 (0.0)	9.00 (0.0)	9.00 (0.0)	8.90 (0.4)	8.81 (0.6)	8.90 (0.2)	9.00 (0.0)	9.00 (0.0)
Number of rays in anal fin	5.00 (0.0)	5.00 (0.0)	5.00 (0.0)	5.00 (0.0)	5.07 (0.3)	5.00 (0.0)	5.00 (0.0)	5.00 (0.0)
Number of rays in pectoral fin	13.00 (0.0)	13.00 (0.0)	13.00 (0.0)	12.85 (0.7)	11.97 (0.3)	12.90 (0.3)	13.00 (0.0)	13.00 (0.0)
Number of rays in pelvic fin	8.00 (0.0)	8.00 (0.0)	8.00 (0.0)	7.90 (0.8)	7.97 (0.3)	8.00 (0.2)	8.00 (0.0)	8.00 (0.0)
Number of rays in caudal fin	18.80 (0.4)	19.00 (0.0)	19.00 (0.0)	18.60 (0.5)	18.29 (0.8)	18.08 (0.3)	19.00 (0.0)	19.00 (0.0)
Number of scales in lateral line	47.80 (2.3)	54.80 (1.3)	50.30 (1.8)	54.32 (1.8)	50.73 (1.5)	52.00 (1.8)	57.90 (1.7)	55.37 (2.1)

Table II (continued)

	Tripolamos (10)	Danube	Edesseos (12)	Evinos (3)	Gallikos (14)	Kalamas (7)	Mornos (2)	France
Morphometric variables								
Standard length	122.05 (18.7)	87.86 (27.7)	113.54 (10.8)	111.72 (20.7)	68.86 (10.4)	114.79 (21.5)	112.3 (20.6)	113.93 (22.6)
Maximum body depth	26.43 (3.7)	19.67 (6.1)	26.84 (3.3)	25.85 (3.3)	17.09 (3.2)	26.16 (3.7)	24.31 (3.9)	29.62 (5.5)
Minimum body depth	12.48 (1.7)	9.05 (2.3)	12.81 (1.2)	12.47 (1.4)	7.75 (1.8)	12.54 (1.6)	12.15 (1.9)	14.23 (2.9)
Caudal peduncle length	22.37 (3.1)	14.67 (4.7)	20.53 (2.5)	21.53 (3.3)	11.41 (2.2)	20.69 (3.2)	21.09 (3.8)	19.02 (4.0)
Head length	29.77 (4.1)	22.10 (7.1)	29.21 (2.6)	28.76 (3.8)	17.25 (2.2)	28.53 (4.1)	27.62 (4.8)	28.62 (5.5)
Diameter of eye	5.25 (0.4)	4.36 (0.8)	5.18 (0.3)	5.74 (0.5)	4.39 (0.6)	4.91 (0.3)	5.40 (0.3)	6.00 (0.8)
Preorbital distance	12.63 (2.1)	9.39 (3.1)	11.71 (1.3)	11.54 (2.1)	6.43 (1.2)	11.14 (1.9)	11.06 (2.4)	9.66 (2.3)
Postorbital distance	14.32 (2.4)	10.46 (3.2)	14.08 (1.3)	13.25 (1.9)	7.96 (1.3)	13.55 (2.2)	12.84 (2.8)	13.97 (3.2)
Dorsal fin height	16.17 (2.6)	11.29 (3.7)	14.13 (1.4)	13.92 (2.1)	8.81 (1.4)	15.06 (2.5)	13.48 (2.4)	20.21 (4.6)
Dorsal fin base length	25.75 (5.8)	18.29 (7.1)	24.60 (3.7)	25.95 (4.7)	13.05 (2.7)	22.72 (4.7)	24.52 (5.9)	14.23 (3.9)
Anal fin height	10.24 (1.9)	7.36 (2.2)	8.95 (1.1)	8.44 (1.6)	6.29 (1.9)	8.99 (1.5)	8.03 (1.7)	24.99 (6.4)
Pectoral fin length	21.11 (3.1)	16.61 (5.2)	21.23 (1.9)	23.29 (2.9)	12.36 (1.7)	21.47 (2.9)	23.28 (4.1)	22.78 (3.2)
Pelvic fin length	17.68 (2.4)	14.33 (4.1)	17.60 (1.5)	19.24 (2.6)	10.39 (1.6)	17.75 (2.4)	19.60 (3.6)	16.50 (3.2)
Distance pectoral - pelvic fin	36.69 (5.8)	25.98 (9.6)	33.95 (3.7)	32.09 (4.6)	20.20 (3.2)	35.42 (5.8)	32.44 (6.2)	34.43 (5.4)
Distance pelvic - anal fin	18.63 (5.4)	19.82 (6.5)	25.86 (2.8)	25.68 (4.2)	15.74 (2.6)	27.43 (4.5)	26.24 (5.4)	26.38 (5.7)
Distance dorsal - pectoral fin	38.55 (6.0)	26.31 (8.1)	35.39 (3.7)	34.74 (4.4)	22.09 (3.4)	36.35 (5.4)	33.93 (6.2)	39.46 (5.5)
Distance dorsal - pelvic fin	25.63 (3.7)	18.37 (5.8)	26.00 (2.8)	24.67 (3.2)	15.58 (2.5)	25.46 (3.8)	23.74 (4.5)	29.17 (4.6)
Distance dorsal - anal fin	39.29 (6.6)	27.72 (9.6)	36.93 (3.8)	35.89 (5.4)	22.72 (3.6)	37.48 (6.1)	34.34 (6.3)	37.00 (7.9)
Distance dorsal - caudal fin	62.45 (10.1)	44.02 (14.9)	56.75 (5.8)	56.31 (8.3)	34.94 (6.1)	59.68 (8.8)	56.72 (10.7)	56.92 (12.3)
Distance anal - caudal fin	37.27 (4.6)	22.69 (6.8)	29.46 (3.1)	30.18 (4.3)	17.97 (3.2)	30.51 (4.8)	29.84 (5.7)	31.50 (5.6)
Meristic variables								
Number of rays in dorsal fin	9.00 (0.0)	9.00 (0.0)	9.00 (0.0)	9.00 (0.0)	9.00 (0.0)	9.00 (0.0)	9.00 (0.0)	9.00 (0.0)
Number of rays in anal fin	5.00 (0.0)	5.00 (0.0)	5.00 (0.0)	5.00 (0.0)	5.00 (0.0)	5.00 (0.0)	5.00 (0.0)	5.00 (0.0)
Number of rays in pectoral fin	13.00 (0.0)	13.00 (0.0)	13.00 (0.0)	13.00 (0.0)	13.00 (0.0)	13.00 (0.0)	13.00 (0.0)	13.00 (0.0)
Number of rays in pelvic fin	8.00 (0.0)	8.00 (0.0)	8.00 (0.0)	8.00 (0.0)	8.00 (0.0)	8.00 (0.0)	8.00 (0.0)	8.00 (0.0)
Number of rays in caudal fin	19.00 (0.0)	19.00 (0.0)	19.00 (0.0)	19.00 (0.0)	19.00 (0.0)	19.00 (0.0)	19.00 (0.0)	18.00 (0.0)
Number of scales in lateral line	55.37 (2.1)	55.47 (3.4)	52.74 (1.9)	50.22 (1.7)	53.10 (2.5)	52.14 (2.2)	50.87 (1.1)	49.66 (2.1)

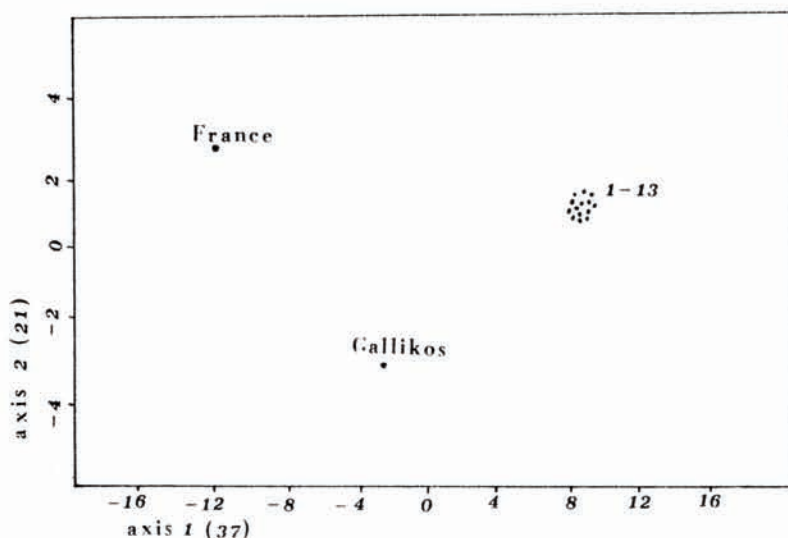


Fig. 3. - Discriminant analysis plot using the morphometric characters of *B. peloponnesius* and *B. meridionalis* populations. The points indicate group centroid and the numbers refer to the collection sites in figure 1. In parentheses: percent of variance expressed on each axis.

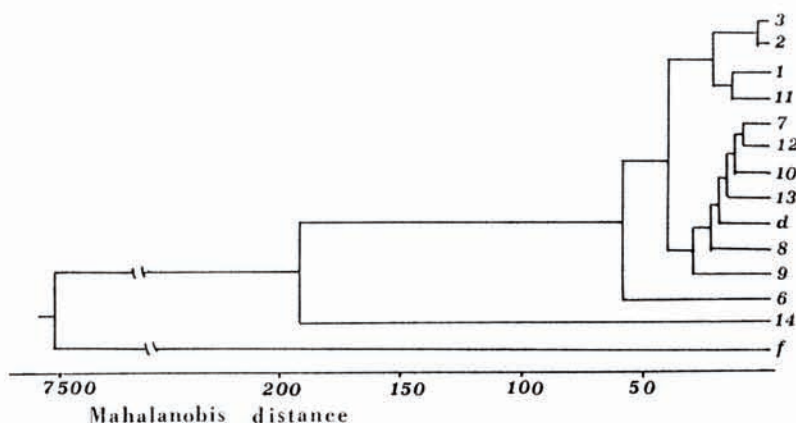


Fig. 4. - A UPGMA (unweighted pair-group method with arithmetic averaging) dendrogram based on the Mahalanobis distance of fourteen populations of *B. peloponnesius* and *B. meridionalis*. The numbers refer to the collection sites in figure 1. d = Danube, and f = France.

the boundary of the distribution of the *B. peloponnesius* and *B. cyclolepis* species (Economidis and Voyadjis, 1985; Economidis 1989, 1990); according to the last author *B. cyclolepis* had penetrated into the distribution area of *B. peloponnesius* at the eastern tributaries of the Axios river system very close to Gallikos river. Since the area to the west of this river is a lowland with many channels connecting the two river systems, penetration by *B. cyclolepis* seems to be possible (Fig. 9). Thus, the Gallikos population could be an introgressed stock. Such introgression events could have happened at species boundaries and have been detected between *B. meridionalis* and *B. haasi* in Spain (Machordom *et al.*,

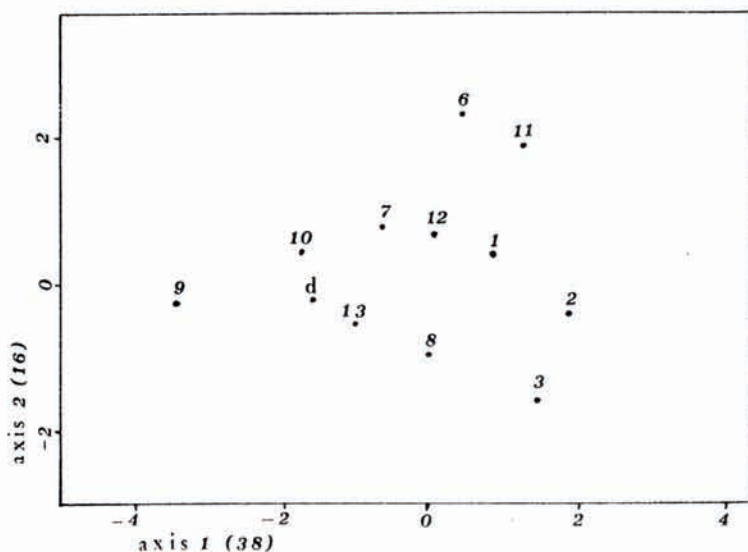


Fig. 5. - Discriminant analysis plot of twelve populations of *B. peloponnesius*. The points indicate the group centroid and the numbers refer to figure 1; d = Danube. In parentheses: percent of variance expressed on each axis.

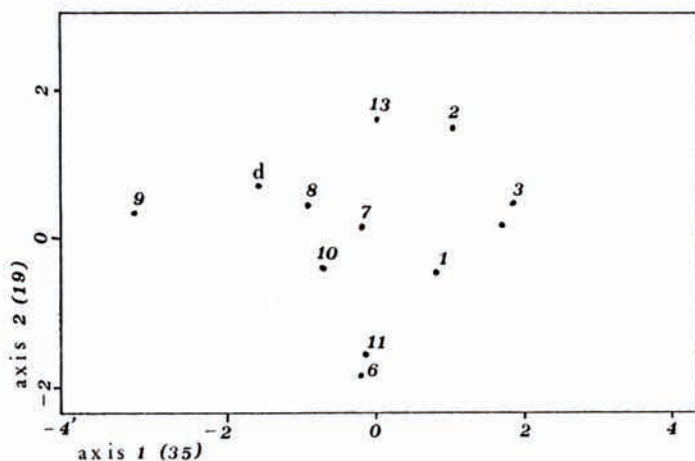


Fig. 6. - Discriminant analysis plot of twelve populations of *B. peloponnesius* using the "Truss network" method. The points indicate group centroid and the numbers refer to figure 1; d = Danube. In parentheses: percent of variance expressed on each axis.

1990) and between *B. meridionalis* and *B. barbus* (Berrebi *et al.*, 1989). The Gallikos population has been investigated at the isozymic level (Triantaphyllidis *et al.*, 1981) but unfortunately there is no information about isozymes of *B. peloponnesius* and *B. cyclolepis* to confirm the suggested introgression. Meristic characters provide little help because *B. cyclolepis* and *B. peloponnesius* only differ by the number of denticles of the 4th ray of the dorsal fin (Karaman, 1971) and by the greater number of scales in the lateral line.

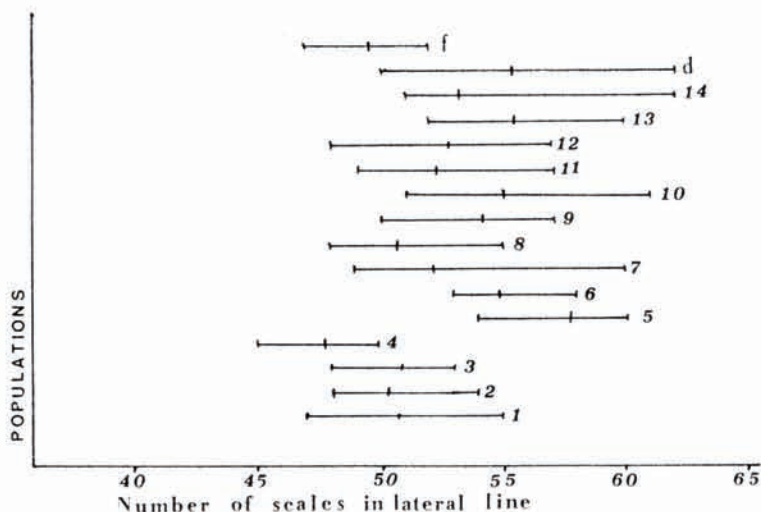


Fig. 7. - Number of scales in the lateral line of *B. peloponnesius* (1-14), *B. meridionalis* (f) and *B. m. petenyi* (d) samples.

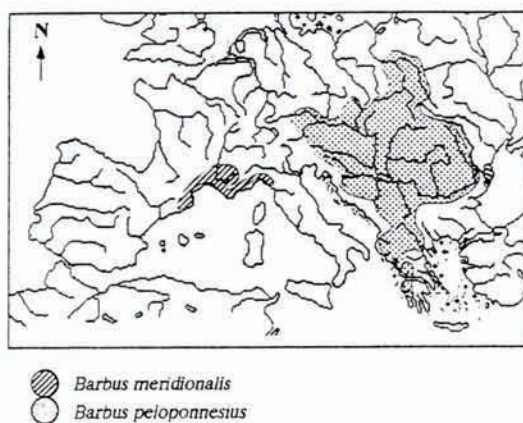


Fig. 8. - Distribution pattern of *B. m. meridionalis* and *B. peloponnesius*.

The Gallikos population also falls into the higher range in number of lateral line scales, but it is within the range of variation of most of the samples. Discriminant analysis of the morphometric characters indicated that the differentiation of the Gallikos population is based on the height of dorsal fin and the maximum body depth. We cannot also exclude the possibility that this population is showing an ecophenotypic variation. Which would not be surprising because the Gallikos river is very shallow and sporadically dries up.

These results demonstrate the need for more information about the genetic structure of *B. peloponnesius* to clarify its affinities in relation to other species. We have thus initiated a programme of screening these populations at the isozymic and mtDNA level as well.

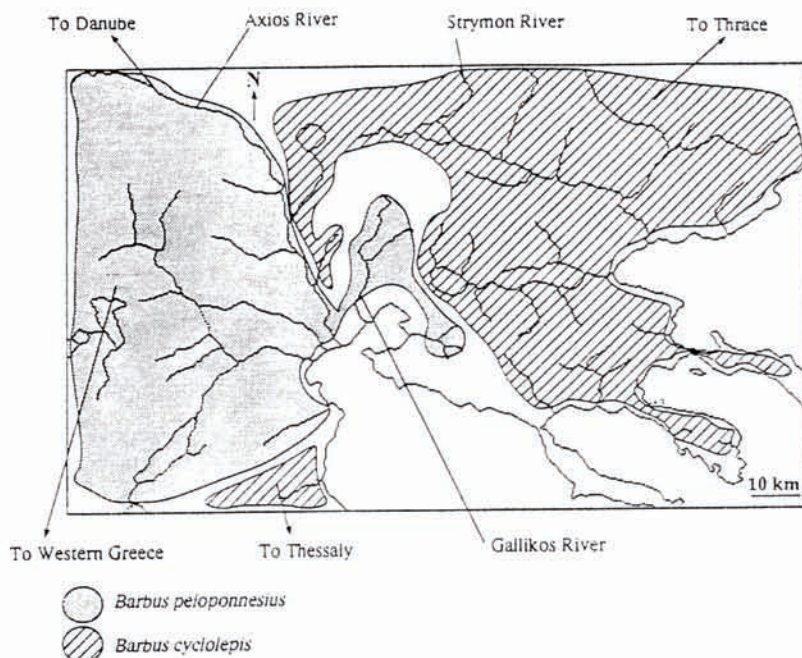


Fig. 9. - Contact zone and distribution of *B. peloponnesius* and *B. cyclolepis* species at the Gallikos river system area.

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